Food Security, Inclusive Growth, Sustainability, and the Post-2015 Development Agenda

BACKGROUND RESEARCH PAPER

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This paper reflects the views of the author and does not represent the views of the Panel.

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FOOD SECURITY, INCLUSIVE GROWTH, SUSTAINABILITY, AND THE POST-2015 DEVELOPMENT AGENDA

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The views expressed herein are the authors' and do not necessarily reflect those of the World Resources Institute

Summary

Over the next several decades, the world faces an historic challenge and opportunity at the nexus of food security, economic development, and the environment. The world needs to be food secure. The world needs agriculture to contribute to inclusive economic development. And the world needs to reduce agriculture's impact on the environment.

This nexus has several implications for policymakers as they outline a post-2015 development agenda. First, it is critical that the post-2015 development agenda has an explicit goal on food security. Second, it is important that any goal on food security include some sustainability targets and indicators. Third, suitable candidate sustainability targets include a target on the rate of food loss and waste, low-carbon agriculture, and water-efficient food production, to name a few (Table 1).

These candidate targets satisfy several parameters. They acknowledge that food security is worthy of a dedicated post-2015 goal. They recognize that food security is dependent, at least in part, on the sustainability of food supply. They ensure that the means of implementation associated with any suite of food security-related targets would avoid practices that exacerbate any negative impacts of food production or consumption on climate, water, and ecosystems. They satisfy core principles of poverty alleviation, human well-being, sustainability, universality, and multiple tiers of action. And they encourage government policy coherence.

If the post-2015 development agenda were to adopt the proposed food security targets, the world would take a measurable step toward adequately and fairly feeding a growing population in a manner that alleviates poverty and advances economic development while reducing pressure on its natural resources.

Table 1. Proposed food security targets that integrate sustainability

Target relative to 2015	Indicator	Metric
By 2030, reduce the rate of food loss and waste by 50 percent	Share of food produced or harvested that is lost or wasted between the farm and fork	Percent of food loss and waste
By 2030, reduce the greenhouse gas emissions from food production by 25 percent	Total greenhouse gas emissions from food production, including both crops and livestock	Tons of carbon dioxide equivalent
By 2030, reduce the water-intensity of agricultural production by 25 percent	Tons of food produced per cubic meter of irrigation water consumed to generate those tons	Tons per cubic meter of water

I. The Food Security Challenge

Over the next several decades, the world faces a grand challenge—and opportunity—at the nexus of food security, economic development, and the environment.

First, the world needs to be food secure. The United Nations Population Division projects the global human population to grow from 7 billion in 2012 to 9.3 billion by 2050.[1] Forty-seven percent of the population growth will be in sub-Saharan Africa,[2] where agricultural productivity and soil quality is exceptionally low and where reliance on imports of basic staples is already high. Moreover, at least 3 billion people will enter the global middle class by 2030,[3] and they will demand more resource-intensive foods such as meats and vegetable oils.[4] At the same time, approximately 870 million of the world's poorest people remain under-nourished even today.[5] Many poor households are already close to the margins, as shown when food riots in 2008 broke out in more than 25 countries in response to spikes in food prices, which had left many people unable to afford basic food staples.[6] To sufficiently feed all people by 2050, worldwide food availability[7] (in caloric content) will need to increase by roughly 64 percent from 2006 levels.[8] Since the majority of the world's farms are operated by smallholders,[9] and it is generally on their farms that the larger productivity gaps exist,[10] a large part of any supply increase will need to come from them.

Second, the world needs agriculture to contribute to inclusive economic development. Although agriculture directly accounts for approximately 3 percent of global gross domestic product (GDP), it employs more than 2 billion people around the world.[11] Many of the world's poorest people are themselves farmers and, according to the World Bank, GDP growth originating in agriculture can be more effective at reducing poverty than growth arising from other economic sectors.[12] Women comprise 41 percent of the agricultural workforce worldwide and make up the majority of agricultural workers in South Asia and sub-Saharan Africa.[13] Because increasing income to women has disproportionate benefits for alleviating hunger,[14] boosting opportunities for women in agriculture has great significance.

Third, the world needs to reduce agriculture's impact on the environment and natural resources. Agriculture is a major contributor of greenhouse gas emissions, the largest consumer of freshwater among economic sectors, and the largest cause of conversion of natural ecosystems. Going forward, agriculture will need to adapt to a changing climate in order to ensure adequate food production. At the same time, when done right, agriculture can provide numerous benefits beyond food production and jobs including building material, soil fertility, and more.

The convergence of these three needs poses one of the paramount challenges of the next several decades: *How can the world adequately and fairly feed a growing population in a manner that alleviates poverty and advances economic development while reducing pressure on natural resources*? This Background Paper provides several perspectives on answering this question. Through a number of core propositions, it makes the case that integrating sustainability considerations into a post-2015 global goal on food security and nutrition will be critical to the goal's achievement. It continues by recommending several targets—along with their associated indicators and means of implementation—that would incorporate some important sustainability considerations into such a food security goal.

This Background Paper focuses on the sustainability dimensions of food given their significant importance in underpinning long-term food security. It does not focus on other dimensions of food security such as access or utilization. Although we recognize these are critically important aspects of food security, they are beyond the scope of our analysis.

II. Meeting the Food Security Challenge – Six Core Propositions

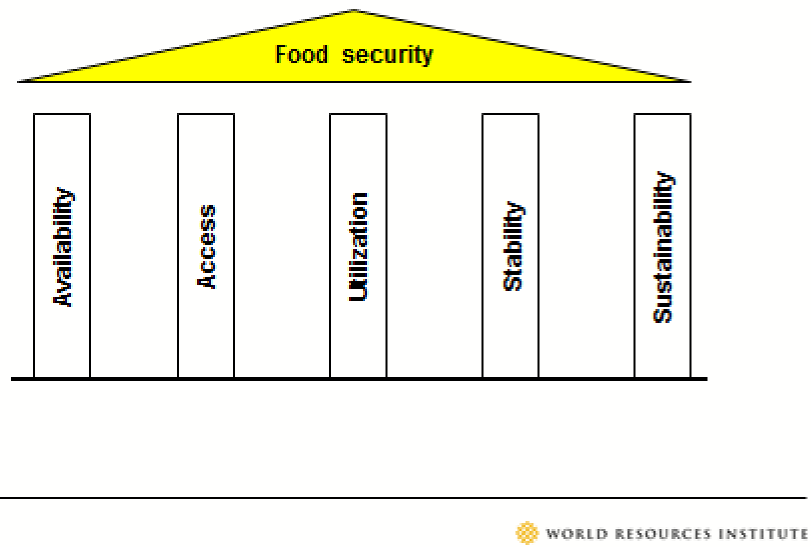
1. Food security is multi-dimensional.

According to the United Nations Food and Agriculture Organization (FAO), "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."[15] Implicit in this definition is the recognition that food security is multi-dimensional. There have been many formulations of what the components of food security are. For instance, the Committee on World Food Security identified four main dimensions or "pillars":[16]

- *Availability* is ensured if adequate amounts of food are produced and are ready to have at people's disposal.
- *Access* is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods (through production, purchase, or donation) for a nutritious diet.
- *Utilization* is ensured when the human body is able to ingest and metabolize food. Nutritious and safe diets, an adequate biological and social environment, and a proper health care to avoid diseases help achieve adequate utilization of food.
- *Stability* is ensured when the three other pillars are maintained over time.

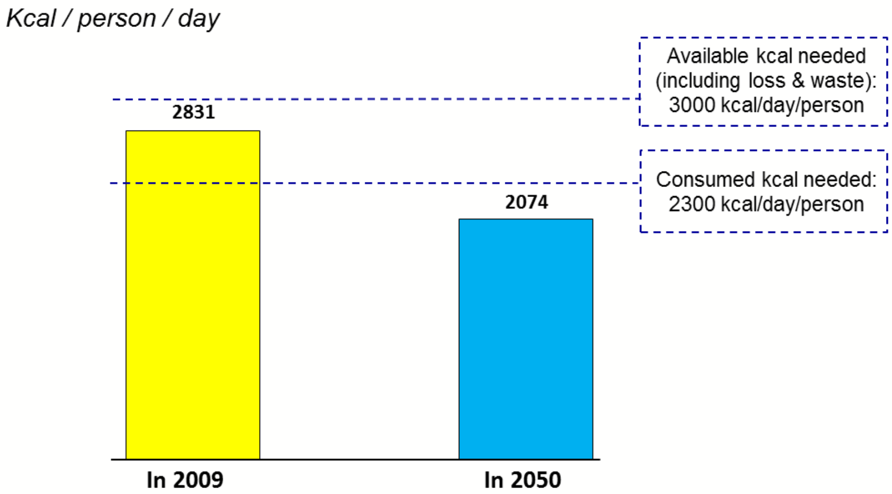
Several experts have noted the need for a pillar on environmental sustainability, where food production and consumption patterns do not deplete natural resources or the ability of the agricultural system to provide sufficient food for future generations.[17] Therefore, for the purposes of this Background Paper, we identify five pillars of food security (Figure 1).

Figure 1. Pillars of food security



2. Achieving food security will require increasing not only food access but also food supply. Given the unequal distribution of food today around the planet, one might think that food security could be achieved by only improving food access and ensuring that the food already generated is distributed more equally among the world's population. Yet, even if all of the food available in the world today were equally distributed on a caloric basis across the entire projected population of 2050, those calories would still fall short of the FAO's "average daily energy requirements" by more than 200 kilocalories (kcal) per person per day, assuming none of those food calories were lost or wasted between the farm and fork (Figure 2). The shortfall would be more than 900 kcal per person per day if the current rate of food loss and waste—24 percent of all produced calories per year—were to remain unchanged in 2050.[18] The world will need to increase food supply as part of the solution to food security—and in an increasingly resource-constrained world, this implies increasing productivity.

Figure 2. Food calories available per person if all the food produced in 2009 were evenly distributed across the entire population



Note: Data reflects food for direct human consumption. It excludes food crops grown for animal feed and biofuels. "Available kcal needed" is the estimated global average daily energy requirement (ADER) per person for 2050 plus the food loss and waste associated with it. "Consumed kcal needed" is the estimated global ADER for 2050—what is ultimately consumed.
Source: WRI analysis based on FAO Stat (2012); UN Population Division. 2011. *World Population Prospects: The 2010 Revision*. Medium growth scenario.

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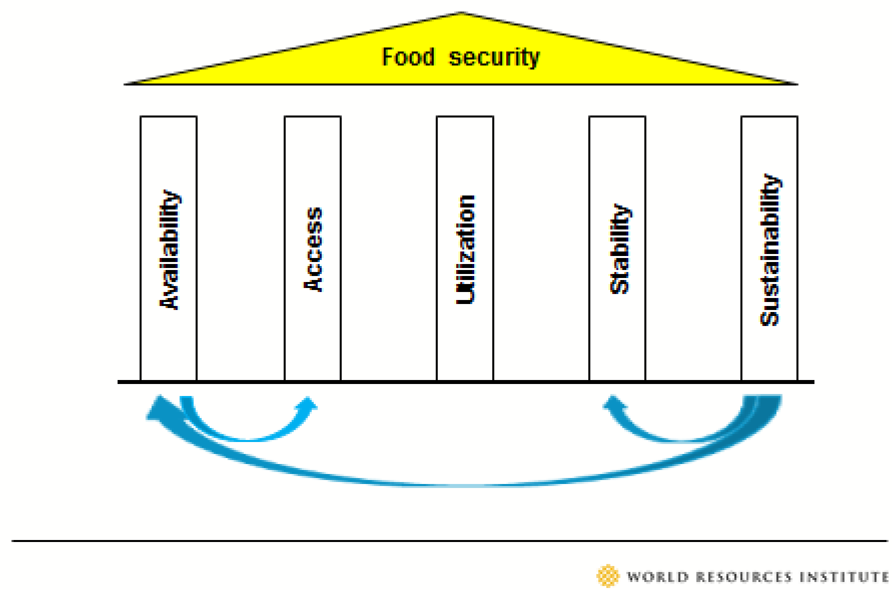
3. Food supply is dependent on environmental sustainability.

The sustainability dimension is an oft overlooked but important pillar, particularly since it underpins many of the others (Figure 3). For instance, food availability is dependent on the state of the environment and the natural resource base. The current global food production system—what is grown where, how, and when—has evolved within a climate that has been relatively stable over the past 8,000-10,000 years. Production of rain-fed and irrigated crops is dependent on supplies of freshwater at appropriate levels at the appropriate times during the growing season. Natural ecosystems located in or around farmland underpin agricultural productivity by providing soil formation, erosion control, nutrient cycling, pollination, wild foods, genetic material, regulation of the timing and flow of water, and more.[19] Furthermore, oceans and inland water bodies currently contribute 16 percent of global animal-based protein supply and are the primary source of such protein for nearly 1.3 billion people.[20]

Figure 3. Links between selected pillars of food security



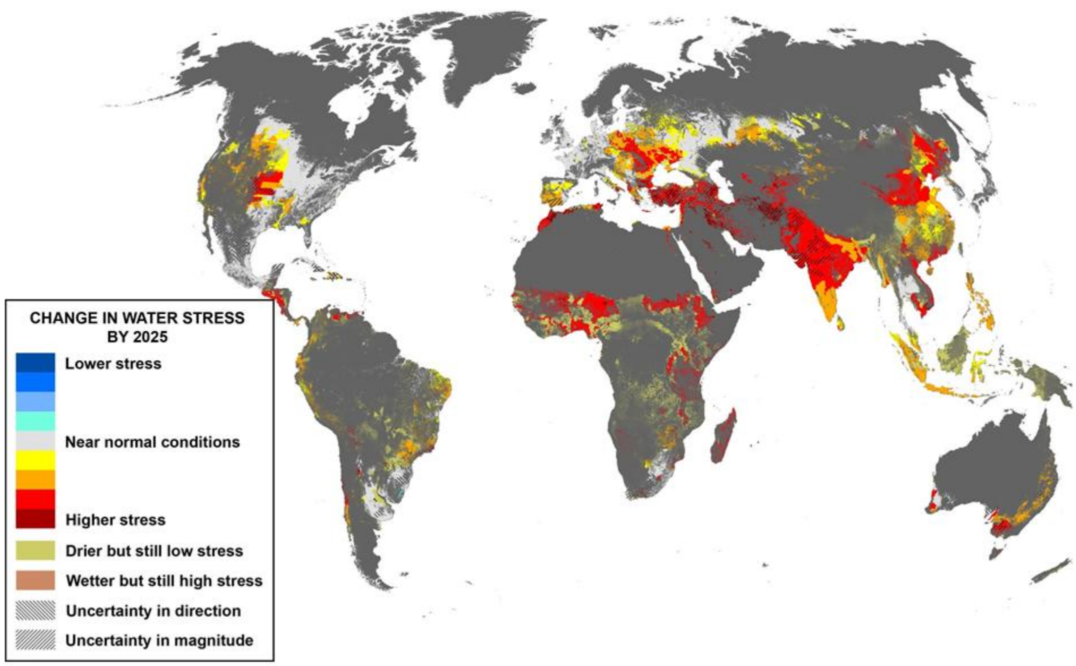
In turn, access is partly dependent on availability. For example, food supplies in a region can become constrained when crop yields decline due to extended heat waves or lack of sufficient water to irrigate crops. As a result, the price of food can increase or access to locally produced food can become constrained, thereby increasing dependence of local populations on food imports. And when this occurs in regions where people do not have sufficient income, economic access becomes an acute food security issue. Likewise, sustainability by definition underpins long-term stability. If food production is not sustainable from an environmental perspective, then it is not stable over time.

4. But many of the environmental underpinnings of food supply are being degraded or are facing limits, making attaining food security more difficult.

Many of the environmental foundations of food supply currently face challenges of resource scarcity and degradation:

- *Climate change.* The global average surface temperature increased by 0.7 degrees C from 1901-2000 and is projected to increase another 1.1 degrees C to 6.4 degrees C by the end of the 21st century.[21] Climate change is projected to lead to changes in precipitation patterns, in the amount and duration of extended heat waves and droughts, and in sea levels, which in turn will impact cropland productivity and viable cropland area.[22]
- *Terrestrial ecosystems.* The conversion of natural ecosystems has led to a decline over the past half century in the quantity and quality of 60 percent of ecosystem services analyzed by the U.N. Millennium Ecosystem Assessment.[23] Many of the ecosystem services, such as soil formation, aquifer recharge, flood control, and more, are important for farmland productivity. Furthermore, land degradation affects approximately 20 percent of the world's cultivated areas.[24]
- *Water.* Many crop-generating regions currently face significant water stress, where near-term demand outstrips supply. The recent droughts and associated declines in crop production in parts of Australia, East Africa, Russia, and the United States are cases in point. Over the coming decades, water stress is projected to increase due to growing demand for water and poor water management, coupled with the impacts of climate change (Figure 4).

Figure 4. Change in water stress by 2025 in agricultural areas



Note: Based on IPCC Scenario A1B
Source: WRI Aqueduct 2012; Water stress data from The Coca-Cola Company. Cropped areas from Ramankutty et al. 2008. "Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000".
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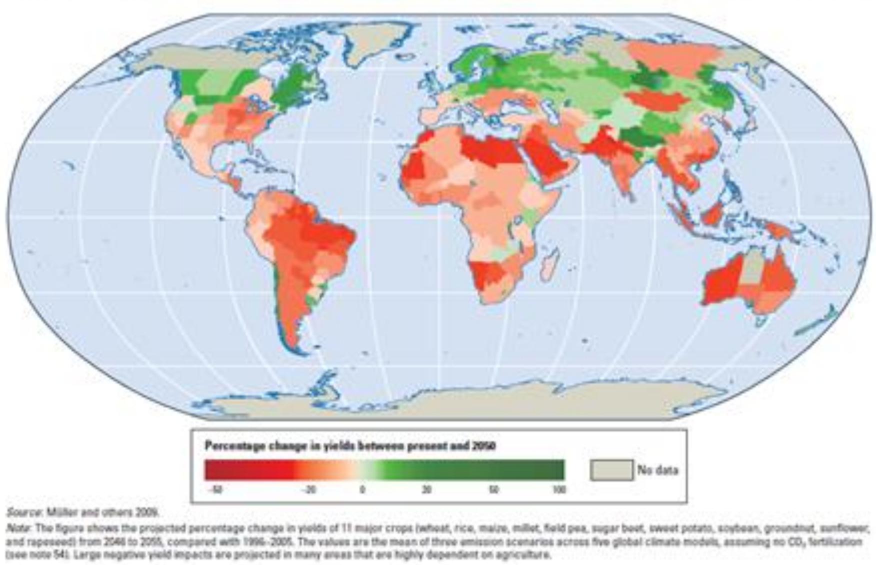
- *Oceans.* Wild fish landings from marine and inland water bodies have stagnated over the past 20 years, gradually declining from a peak of 95 million tons in the mid-1990s to roughly 90 million tons by 2010.[25]

Failure to address these environmental and natural resource impacts will likely hamper food supply and therefore food security. For instance, crop productivity can suffer when soil organic matter, erosion control, and pollination decline as natural ecosystems are converted or degraded.[26] Depleting freshwater aquifers poses a threat to food production in several major breadbaskets.[27] Wild fish catch are projected to decline in coming decades if more fish stocks become fully exploited.

Climate change, in particular, threatens to have major impacts. For example, the latest science indicates that climate change will have net adverse consequences for global crop yields due to higher temperatures, extended heat waves, and shifting precipitation patterns (Figure 5).[28] By mid-century, yields of wheat, maize and soybean could decline by 14-25 percent, 19-34 percent, and 15-30 percent, respectively, with a warming of 2.2 to 3.2 degrees C compared with pre-industrial temperatures and no carbon dioxide fertilization.[29] With a one meter rise in sea levels, almost 11 percent of South Asia's agricultural land is projected to be vulnerable to flooding.[30] By the end of the century, the planet's "drought disaster affected area" is projected to grow from 15 percent to approximately 44 percent, with regions facing the greatest increases being southern Africa, the United States, southern Europe, Brazil, and Southeast Asia.[31]

Figure 5. Projected climate change impact on crop yields (3° C world)



Note: Map is based on the average of three climate scenarios, which is equivalent to approximately 3 degree C increase by 2050.
Source: *World Development Report 2010*. 2010. World Bank.

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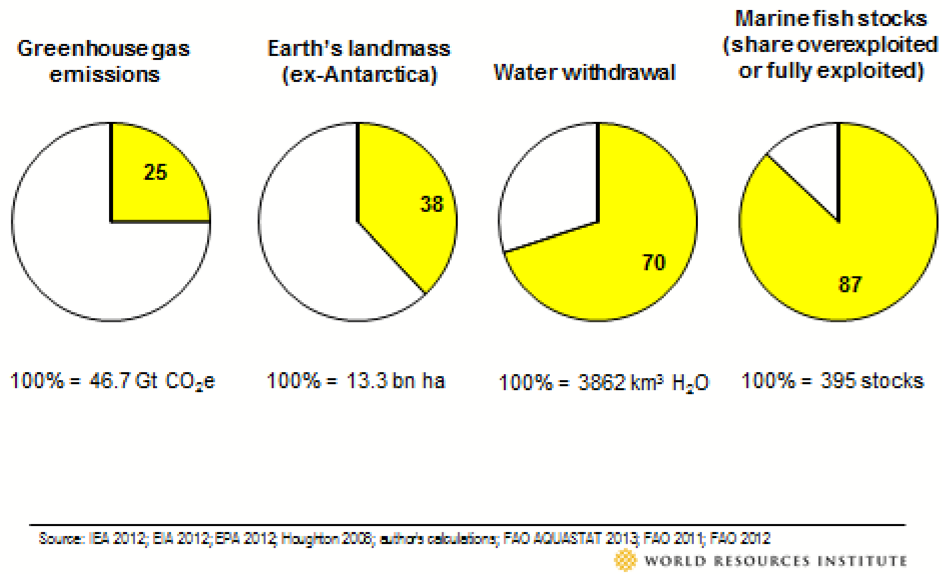
5. The food production system itself is contributing to this degradation.

The global food production system itself contributes to this environmental degradation in several ways (Figure 6):

- *Climate change.* Agriculture accounts for approximately 25 percent of global greenhouse gas emissions as of 2010. About 14 percent of emissions are from the food production process including methane from livestock, nitrous oxide emissions from fertilizer use, and energy used for fertilizer manufacturing and tractors. Approximately another 11 percent results from land-use change, which is primarily driven by agriculture.[32]
- *Terrestrial ecosystems.* Since the dawn of the first agricultural revolution 8,000-10,000 years ago, growing crops and raising livestock have been the primary cause of loss and degradation of natural ecosystems.[33] Today, 38 percent of the planet's landmass outside of Antarctica is already dedicated to growing food; 12 percent is in croplands and 26 percent is in grazing lands.[34]
- *Water.* Agriculture is responsible for approximately 70 percent of the world's freshwater withdrawals[35] and up to 85 percent of its freshwater consumption.[36] Agriculture also has a major impact on water quality; nutrient runoff from farm fields plays a major role in creating "dead zones" and otherwise degrading coastal waters globally.[37]
- *Oceans.* While the global wild fish catch has stagnated over the past 20 years, the percentage of stocks that are overfished continues to rise. In 2009, for instance, 30 percent of marine fish stocks were classified as overexploited and another 57 percent were fully exploited, while only 13 percent were exploited at less than their full potential.[38] Fishing now occurs across one-third of the world's ocean surface, leaving

Figure 6. Food production system's share of global impact (~2010)
Percent



only the most inaccessible waters at the two poles and the unproductive waters of the high seas unexploited.[39]

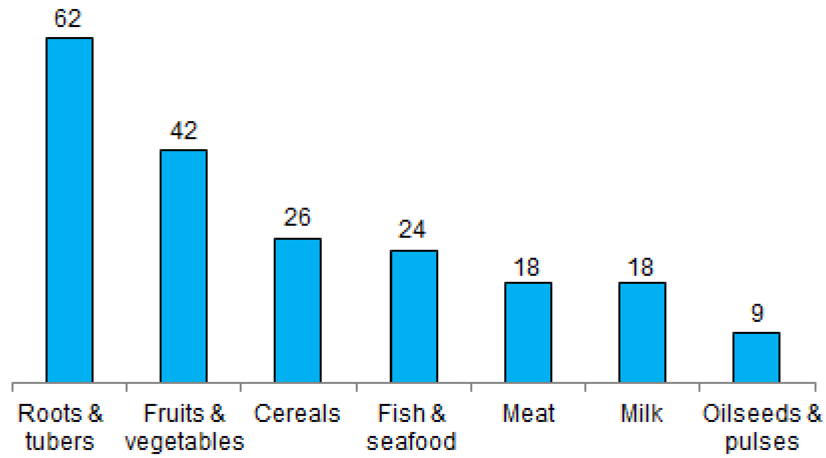
6. Food consumption patterns also are impacting the sustainability of food security.

How food is produced is not the only facet of the food production system impacting the sustainability and equity of food security. How food is consumed has implications as well. Three consumption-side issues of particular relevance are food loss and waste, overconsumption, and competing uses of food.

Food loss and waste. Measured in caloric content, 24 percent of all food produced is lost or wasted between the farm and the fork.[40] In terms of share of harvested crop by commodity, roots and tubers experience the greatest amount of loss and waste, followed by fruits and vegetables, and about a quarter of cereals and seafood are lost and wasted (Figure 7). Food loss and waste equates to food-insecure people and communities having to grow or pay for even more food to

Figure 7. Share of commodity lost or wasted (2009)

Percent of kcal



Note: Values displayed are of waste as a percent of food supply, defined here as the sum of the "Food" and "Processing" columns of the FAO Food Balance Sheet.
Source: WRI analysis based on Gustavsson et al. 2011.

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meet their energy and nutritional needs. Economically, it equates to wasted financial and labor investments that reduce the income of actors in the food value chain. Environmentally, it equates to wasted water, land, and energy, and unnecessary greenhouse gas emissions.

Over-consumption. More people in the world today consume too much food than consume too little. The World Health Organization estimates that 1.4 billion people are overweight, having a body mass index over 25, and 500 million of them are obese, having a body mass index over 30,[41] whereas about 870 million are undernourished.[42] Besides impacting resource consumption, obesity is a human health and personal finance problem. For instance, according to an OECD study, obese people on average incur 25 percent higher healthcare costs than a person of normal weight.[43]

Competing uses of food crops. Take biofuels for example. Producing 10 percent of the world's liquid transportation fuel by 2050 would require 36 percent of all the world's crops produced in

2010, as measured by their energy content.[44] Indeed, all of the chemical energy contained in 100 percent of all the world's crops in 2011 equaled just 14 percent of the world's primary energy consumption.[45] Such additional demands would make achieving food security even more difficult.

III. Implications for the Post-2015 Development Agenda

A number of implications for the post-2015 development agenda follow from the food security challenge and these six propositions. First, it is critical that the post-2015 development agenda has an explicit goal on food security. Producing and distributing food is a hallmark foundation of human civilization[46] and is a prerequisite for political stability, sustainable development, and inclusive economic growth.[47] At the same time, demand for food is projected to dramatically increase over coming decades. Omitting a goal on food security, therefore, risks diverting global and national attention away from such a basic fundamental need of all people, particularly at a time when such attention is needed most. Likewise, combining a goal on food security with another goal risks food being eclipsed by the other issue. The world needs a dedicated goal on food security.

Second, it is important that any goal on food security include some sustainability targets and indicators. The current suite of MDGs has only one target and two indicators relating to food security (Box 1). This target and its indicators may have served well the 2000-2015 period, but the sustainability challenges and opportunities facing the global food system over coming decades suggest that merely replicating these targets and indicators in the post-2015 world would be insufficient for achieving food security.

Box 1. Food security in the current MDGs

Food security is reflected by one target and two indicators in the current Millennium Development Goals:

- *Target 1.C.* Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
- *Indicator 1.8.* Prevalence of underweight children under five years of age.
- *Indicator 1.9.* Proportion of population below minimum level of dietary energy consumption.

Third, suitable candidate sustainability targets include a target on the rate of food loss and waste, low-carbon agriculture, and water efficient food production, to name a few. That said, not every target and indicator associated with a food security goal needs to be sustainability-oriented. For example, targets relating to nutrition levels, prevalence of stunting, or share of underweight (and overweight) children under five years of age will continue to be relevant and worthy of inclusion in a post-2015 global goal on food security.

Finally, any target should align with some core principles for the post-2015 development agenda, including:[48]

- *Poverty and well-being:* Eradicating multi-dimensional poverty and improving the well-being and security of people and the planet sustainably should be the overriding objective of the post-2015 agenda.
- *Sustainability:* Global goals, targets, and indicators for poverty eradication and improved well-being must integrate economic, social, and environmental dimensions of sustainability and their inter-linkages, with equity and resilience as cross-cutting priorities.
- *Universality:* A post-2015 agenda to eradicate poverty and achieve sustainable and equitable development must be a shared agenda, whereby goals are applicable to all countries but reflect diverse development pathways and implementation capacities.
- *Multiple tiers of action:* Achieving the goals and targets should be amenable to individual and household actions, national development frameworks, and global collective action.

The following elaborates on three candidate sustainable food security targets.

Food Loss and Waste: Context

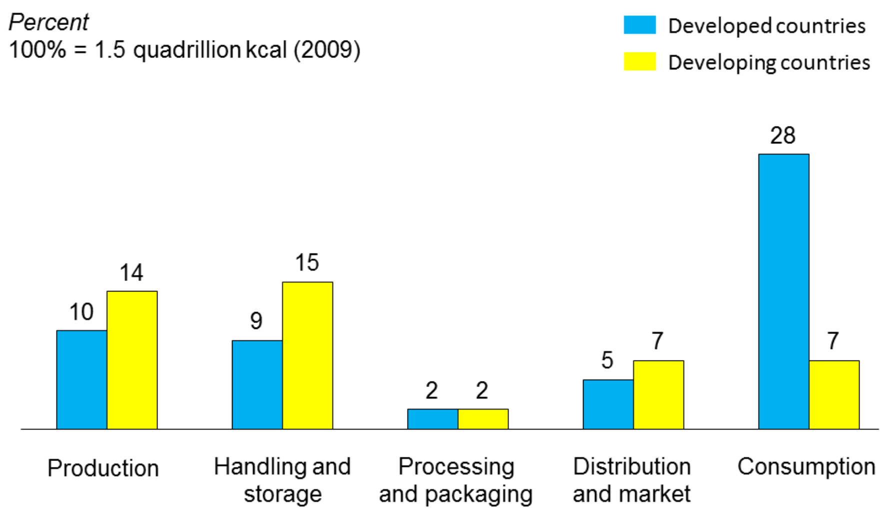
"Food loss and waste" refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people.[49] In particular, "food loss" refers to food that unintentionally gets spilled, spoils, incurs a reduction in quality, or otherwise gets lost before it reaches the consumer. "Food waste" refers to food of good quality and fit for consumption that deliberately does not get consumed because it is discarded—either before or after it is left to spoil.[50] Food loss and waste can occur during any stage of the food value chain, including:

- *Production* or harvest in the form of grain left behind by poor harvesting equipment, discarded fish, and fruit not harvested or discarded because they fail to meet quality standards.
- *Handling and storage* in the form of food degraded by pests, fungus, and disease.
- *Processing and packaging* in the form of spilled milk, livestock trimmings, damaged fish, and fruit unsuitable for processing.
- *Distribution and market* in the form food discarded due to bruises or "sell-by date" expiry.
- *Consumption* in the form of food bought by consumers, restaurants, and caterers but not eaten.[51]

The FAO estimates that 32 percent of all food produced in the world, in terms of weight, was lost or wasted in 2009.[52] However, food types vary widely in terms of their water and caloric content per kilogram. Measured in terms of caloric content, global food loss and waste equated to approximately 24 percent of all food produced.[53] *One out of every four calories produced is not ultimately consumed.*

The distribution of this food loss and waste varies significantly between developed and developing regions (Figure 8). Approximately half of food loss and waste in the developed world occurs at the point of consumption, or "close to the fork." In contrast, two-thirds of food loss and waste in the developing w world occurs during the production stage and the handling and storage stage, or "close to the farm."

Figure 8. Distribution of food loss and waste across the value chain



Note: Numbers may not add to 100 due to rounding. "Developed countries" includes countries in North America, Oceania, Europe, and Industrialized Asia (includes China, Japan, and South Korea). "Developing countries" includes countries in Sub-Saharan Africa, North Africa, West and Central Asia, South and Southeast Asia, and Latin America. Numbers may not sum to 100 due to rounding.
Source: WRI analysis based on FAO. 2011. *Global food losses and food waste – extent, causes and prevention*. Rome: UN FAO.
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Food loss and waste: Candidate target

Such big inefficiencies suggest big opportunities for economic, social, and environmental improvement—and thus a worthy target for the post-2015 development agenda. We propose the following target and its associated indicator and metric:

- *Target:* By 2030, reduce the rate of food loss and waste by 50 percent.
- *Indicator:* Share of food produced/harvested that is lost or wasted between the farm and fork.
- *Metric:* Percent of food loss and waste.

Such a target is ambitious. It implies that the rate of food loss and waste in 2030 would decline from its current level of 24 percent to 12 percent (on a caloric basis) or from 32 percent to 16 percent (on a weight basis). Yet some are already making similarly ambitious goals. In 2012, for example, the European Commission set a target of reducing by 50 percent the rate of food waste in Europe by 2020.[54]

There is precedent for progress. For instance, the Waste and Resource Action Programme (WRAP) in the United Kingdom has achieved a 13 percent reduction in household food waste nationwide from 2007 to 2010.[55] Pilot efforts in Benin, Cape Verde, India, and Rwanda have reduced food loss for a number of commodities by more than 60 percent through a variety of low-cost storage and handling practices.[56]

The target is measurable. The methods from FAO's *Global Food Losses and Food Waste: Extent, Causes, and Prevention* (2011) could be replicated to create a baseline and measure progress. Setting a target would also serve to increase the quality and periodicity of data collection.

Furthermore, the target performs well against the core principles (Table 2).

Table 2. Performance against core principles

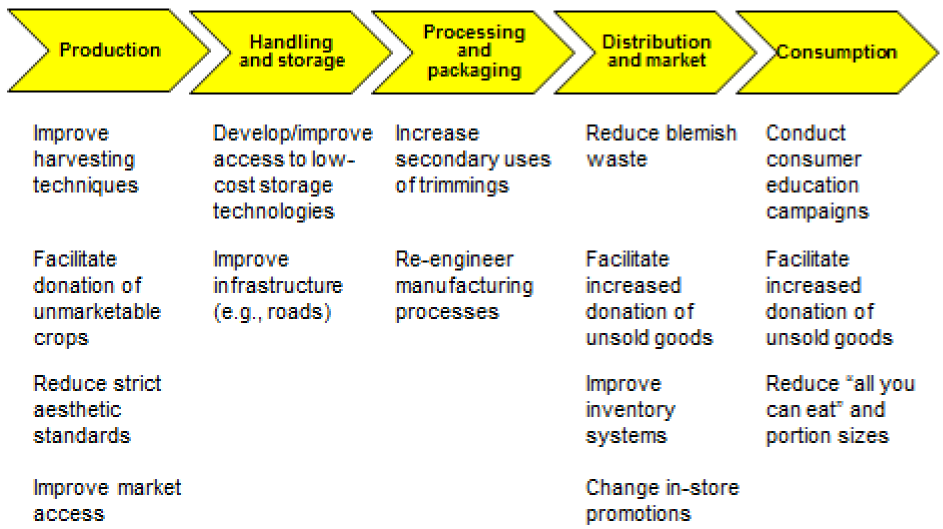
Principle	Reducing food loss and waste could . . .
Poverty and well being	• Increase the share of food grown by small-holder farmers that is available for their own consumption and/or for sale to the market. • Reduce the likelihood that small-holders become net food buyers.
Sustainability	• Lower demands on water, land, and energy, and lower greenhouse gas emissions (environmental). • Reduce the likelihood of social disruption due to acute food scarcity (social). • Curtail wasted financial and labor investments (economic).
Universality	• Involve all countries. For instance, developing countries have much to do to reduce losses at the production and storage stages while developed countries have much to do to reduce waste at the consumption stage.
Tiers of action	• Involve all actors. For instance, households can take steps to reduce waste at home, food retailers can improve food screening and inventory handling procedures, and countries and international institutions can introduce initiatives and policies that improve food storage and handling.

Food loss and waste: Means of implementation

Fortunately, a number of strategies for reducing food loss and waste along the value chain are already known (Figure 9) and, if implemented at scale, could go a long way toward achieving the proposed target. For example:

- For the production step, principle opportunities involve improving harvesting techniques and altering strict aesthetic standards that can encourage farmers to leave tubers and vegetables with surface blemishes in the field.
- For the handling and storage step, one solution is to improve access to simple, low-cost food storage systems for low-income farmers. Another is to improve roads, storage facilities, electricity, refrigeration, and improved food processing in general.
- Ways to reduce loss and waste during the processing and packaging step include increasing secondary uses of trimmings and re-engineering food manufacturing processes.
- Strategies for reducing loss and waste in the distribution and market step include reducing blemish waste at the store, facilitating donation of unsold goods, and improving inventory systems to better match food demand and supply and thus reduce shelf losses.
- For the consumption step, WRAP has launched consumer education campaigns with major retailers, such as the "Love Food, Hate Waste" program that provides practical tips on food storage, how to avoid confusing "sell by" and "use by" dates, and so forth.[57]

Figure 9. Potential solutions to food loss and waste



Sources: WRI analysis based on WRAP 2011 and Gunders 2012.

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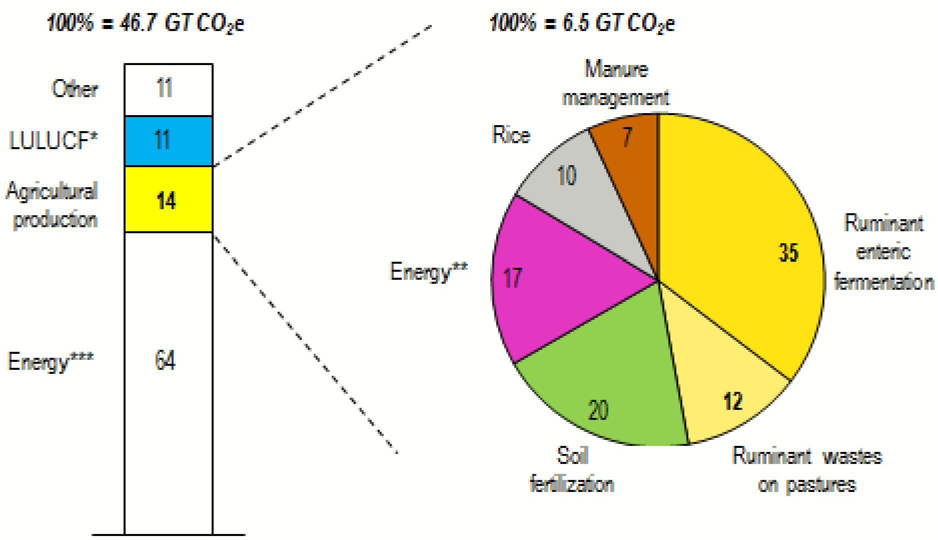
Climate and agriculture: Context

Agriculture is a major contributor of anthropogenic greenhouse gas emissions that are contributing to climate change. As of 2010, agriculture in some form accounted for approximately 25 percent of global greenhouse gas emissions (Figure 10). About 14 percent of emissions came from the food production process, most notably:

- Methane emissions generated through enteric fermentation in the stomachs of ruminants—cattle, goats, and sheep;
- Methane and nitrous oxide emissions from ruminant wastes decomposing on pastures;
- Nitrous oxide emissions from croplands and grasslands, derived particularly from fertilizers;
- Carbon dioxide emissions from on-farm energy consumption as well as from the manufacture of farm tractors, irrigation pumps, other machinery, and key inputs such as fertilizer;
- Methane and nitrous oxide emissions from rice paddies; and
- Methane emissions from the manure managed in storage facilities and barns, primarily from pigs and cattle feedlots.

Approximately 11 percent of global greenhouse gas emissions came from land use, land-use change, and forestry (LULUCF).[58] The majority of land-use change in the world results from agriculture, in the form of the conversion of forests, wetlands, and grasslands into farms and grazing pastures. For instance, agriculture was responsible for roughly 80 percent of tropical deforestation between 2000 and 2010.[59]

Figure 10. Global greenhouse gas emissions by source (2010)
Percent



* LULUCF = Land Use, Land Use Change, and Forestry. ** Includes emissions from on-farm energy consumption as well as from manufacturing of farm tractors, irrigation pumps, other machinery, and key inputs such as fertilizer. It excludes emissions from the transport of food. *** Excludes emissions from energy sources described above. Note: Numbers may not total 100 due to rounding.

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Sources: WRI analysis based on EPA 2012, FAO 2012, EIA 2012, IEA 2012, and Houghton 2008 with adjustments.

Climate and agriculture: Candidate target

Such a large share of greenhouse gas emissions from agriculture suggests a large opportunity for improvement—and thus a worthy target for the post-2015 development agenda. We propose the following target and its associated indicator and metric:

- *Target:* By 2030, reduce the greenhouse gas emissions from food production by 25 percent.
- *Indicator:* Total greenhouse gas emissions from food production, both crops and livestock.
- *Metric:* Tons of carbon dioxide equivalent (CO_2e).

Such a target is ambitious yet roughly aligned with an emissions reduction trajectory to limit global warming to 2 degrees Celsius by mid-century.[60] It implies that the global greenhouse gas emissions from food production would decline from its 2010 level of roughly 6.5 gigatons of CO_2e to 4.9 gigatons of CO_2e in 2030, even as total food production increases.

Data sources for this target already exist. At a minimum, the greenhouse gas emissions to be included in the indicator are those from direct agricultural production, including emissions from livestock and crop production. To the degree that emissions from land conversion to agriculture can be confidently estimated, they should be included, as well. In that case, the current emissions levels and the 2030 target amount on an absolute basis would need to be revised to include land use change emissions.

The target performs well against the core principles (Table 3).

Table 3. Performance against core principles

Principle	Reducing the greenhouse gas intensity of agriculture could . . .
Poverty and well being	• Increase the productivity of small-holder farmers and reduce excess application of expensive inputs.
Sustainability	• Cut global emissions and lower demand for land (environmental). • Generate new jobs and sustain rural livelihoods (social). • Increase productivity of agriculture, stimulate new technologies and agricultural practices, and create new market opportunities (economic).
Universality	• Involve all countries. Every agricultural producing country can do something to make its agriculture more climate-friendly. For instance, some developing countries can increase use of no-till practices and on-farm agroforestry. Some countries with advanced agricultural systems can take steps to improve fertilizer use efficiencies and lower livestock emissions. Flexibility can be provided to accommodate national circumstances and allow countries that can go further the possibility to do so.
Tiers of action	• Involve all actors. For instance, farming households can implement on-farm climate-smart agricultural practices. Countries can introduce policies and incentives to stimulate low-carbon agriculture. International institutions can facilitate financial investment and technology transfer to encourage adoption of these practices.

Climate and agriculture: Means of implementation

A number of strategies exist for reducing the greenhouse gas intensity of food production. For example, to reduce the direct emissions from agricultural production, farmers can:

- Improve livestock feed efficiency and quality;
- Improve efficiency of fertilizer application, most notably less in regions that apply too much, more in regions that apply too little, and with greater precision just about everywhere;
- Use zero-till or reduced-till soil management practices; and
- Implement alternative wetting and drying rice paddy management practices.

To reduce pressure to convert natural ecosystems to cropland, farmers can:

- Boost yields through improved soil and water management practices, including integration of nitrogen-fixing trees and plants in and around farmland;
- Improve yields through more precise management of inputs and careful seed selection; and
- Close the “yield gap” among smallholders.

To reduce pressure to convert natural ecosystems to grazing land, farmers can improve pastureland productivity by:

- Selectively using more grains and high protein oilseed meals as a grass supplement, particularly during the dry or cold seasons when grass production drops off;
- Improving health care for livestock animals and the types of animal breeds so that the animals produce more meat and milk from the same amount of forage and feed;
- Planting pastures with grasses and legumes to produce more digestible forage;
- Grazing animals more efficiently by rotating them among parts of a field; and

- Adding shade trees to reduce animal stress and maintain moisture levels, particularly in tropical areas.

These are only a sample of the wide range of strategies available to achieve this target.

Micro-dosing of fertilizer in Kenya
(Photo: Lukas Bergstrom).

Trees providing shade in a silvopastoral system in Colombia
(Photo: CIPAV).

Water and agriculture: Context

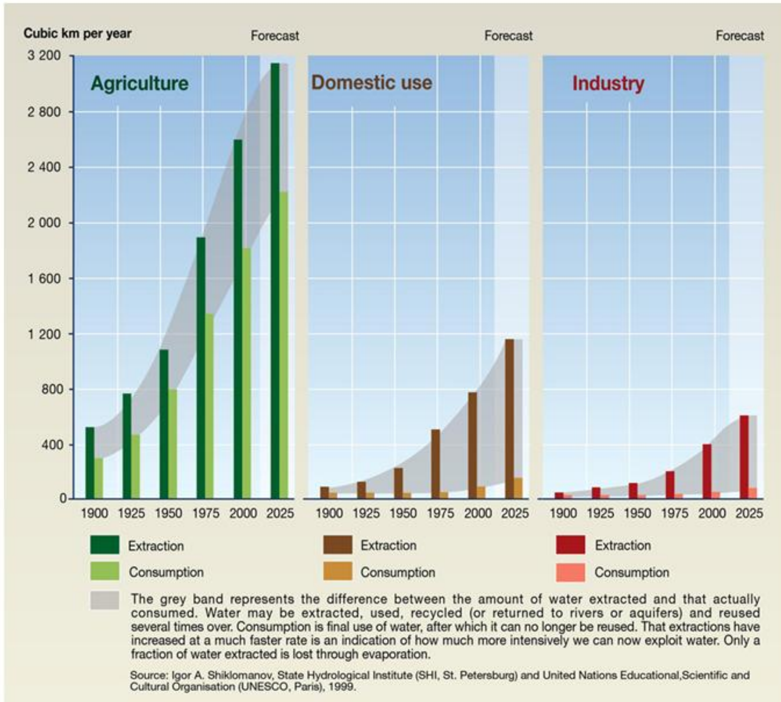
Water is essential for world agricultural output. Water enters the agricultural system in two primary ways—rain-fed agriculture and irrigated agriculture. Rain-fed systems account for 80 percent of cultivated land across the globe and 60 percent of total crop production.[61] Irrigated agriculture accounts for about 20 percent of cultivated land and 40 percent of global food production. Irrigated crop yields are more than two-and-a-half times greater than those of rain-fed agriculture globally.[62]

Much irrigation comes from surface water sources—namely lakes, streams, and rivers. Where these are less available for irrigation, groundwater is tapped. Globally, two-thirds of groundwater use is for irrigation, and the rate of groundwater abstraction has at least tripled over the past 50 years and continues to increase.[63]

Irrigation accounts for 70 percent of total water withdrawals from rivers, lakes, and aquifers globally. In OECD countries, agricultural water withdrawals account for less than half of total withdrawals. But in Brazil, the Russian Federation, India, and China, they account for more than 60 percent, with India's irrigation accounting for as much as 87 percent of its total water withdrawals.[64]

Increased demand for food over coming decades will coincide with increased demand for water for domestic and industrial uses (Figure 11) and climate change. Future global agricultural water consumption, including both rain-fed and irrigated agriculture, is estimated to grow by 19 percent globally by 2050.[65]

Figure 11. Increasing demand for water



Source: UNEP-GRID Arendal. 2008. An Overview of the State of the World's Fresh and Marine Waters – 2nd Edition. Vital Water Graphics. Available online at http://www.unep.org/dewa/vitalwater/article43.html

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Water and agriculture: Candidate target

The water stress that many watersheds may face over coming decades could pose a threat to food security. Having a target aimed at reducing the water-intensity of agricultural production could spur innovation, investment, and adoption of practices that mitigate and adapt to this threat. We propose the following target and its associated indicator and metric:

- *Target:* By 2030, reduce the water intensity of crop production by 25 percent.
- *Indicator:* Tons of food produced (at the farm gate) per cubic meter of irrigation water consumed to generate those tons.
- *Metric:* Tons per cubic meter of water.

Such a target is ambitious and, of course, the relative importance of "tons of food per cubic meter of water" will vary by location; it is more important in water-stressed regions than in those that are water abundant. Data for this target could come from FAO and FAO's Aquastat database, presuming data on water withdrawal can be feasibly converted into water consumption. Furthermore, the target performs well against the core principles (Table 4).

Table 4. Performance against core principles

Principle	Reducing the water intensity of agriculture could . . .
Poverty and well being	• Reduce small-hold farmer and poor community vulnerability to food shortages or price spikes due to droughts. • Protect small-holder yields against competition for available surface water from upstream water users.
Sustainability	• Reduce strain on local water resources, aquatic ecosystems, and water-dependent biodiversity (environmental). • Improve local access to food and sustain rural livelihoods (social). • Increase agricultural productivity, boost farmer incomes, and improve local economies generally (economic).
Universality	• Involve all countries. Every agricultural producing country has opportunities to improve its water-use-efficiency rates in agriculture.
Tiers of action	• Involve all actors. Every actor from individual small-hold farms to very large farming operations, nations, and multinational corporations with large supply chains can take appropriate steps to reduce agriculture-related water use. For example, small-holders can make adjustments in cropping, tillage, and watering techniques. Nations can reform policies to remove incentives for over-irrigation. The private sector can implement standards to improve performance in global supply chains. International institutions can invest in efficient irrigation systems and facilitate technology transfer to encourage adoption of water efficiency practices.

Water and agriculture: Means of implementation

Many strategies exist to reduce the water intensity of food production. For example, to improve the productivity of rain-fed agriculture, farmers can:

- Implement conservation tillage practices such as zero tillage and reduced tillage to maximize rainfall infiltration into soils and reduce run off; and
- Use rainwater harvesting techniques such as contour bunds to maximize water retention in the field.

To reduce overall agricultural water consumption, farmers can:

- Select crops whose water requirements match the water availability of where they are grown;
- Select crops that have lower evapotranspiration-to-productivity ratios or that are adapted to low-water environments; and
- Utilize more effective and precision crop, soil, and nutrient management strategies to ensure higher yields for every liter of water.

To reduce evaporative and leakage losses from irrigation, farmers can:

- Line irrigation canals;
- Ensure the timing and amount of irrigation are tailored to crop requirements; and
- Select efficient irrigation methods, such as micro-drip and subsurface systems, that have low evaporation losses and that are well suited to the location and crop.

These are only a sample of the wide range of strategies available to achieve this target.

Rain-fed contour rice farming in India *(Photo: Vinod Sankar).*

Drip irrigation of wheat fields in Mexico *(Photo: H. Gomez/CIMMYT)*.

IV. Concluding Reflections

These proposed targets for a post-2015 development agenda on food security are important in a number of ways.

First, they acknowledge that food security is worthy of a dedicated post-2015 goal.

Second, they recognize that food security is dependent, at least in part, on the sustainability of food supply.

Third, they ensure that the means of implementation associated with any suite of food security-related targets would avoid practices that exacerbate the negative impacts of food production or consumption on climate, water, terrestrial ecosystems, and oceans.

Fourth, they satisfy the core principles of poverty alleviation, human well-being, sustainability, universality, and multiple tiers of action.

Fifth, they encourage government policy coherence. For instance, there are a number of ways to increase food supplies or otherwise achieve food security that are not aligned with meeting other national or international policy goals and conventions. To illustrate, converting remaining natural forests into grazing land or cropland may increase food production but would at the same time undermine efforts to address climate change (the United Nations Framework Convention on Climate Change) and protect biodiversity (the United Nations Convention on Biological Diversity). Likewise, such conversion might run counter to indigenous rights, efforts to build a robust forest products industry, water supply protection policies, or other national goals. If faithfully pursued, the proposed targets would ensure policy alignment between sectors and global issues.

If the post-2015 development agenda were to adopt the proposed food security targets, the world will take a measurable step toward adequately and fairly feeding a growing world population in a manner that alleviates poverty and advances economic development while reducing pressure on its natural resources.

ENDNOTES

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